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JAPANESE [JP,10-065411,A]

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CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE  
INVENTION TECHNICAL PROBLEM MEANS OPERATION DESCRIPTION OF DRAWINGS  
DRAWINGS

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**CLAIMS**

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**[Claim(s)]**

[Claim 1] The semiconductor device characterized by using a superconducting material for the transmission line (microstrip line) of a microwave monolithic integrated circuit.

[Claim 2] The semiconductor device characterized by using the propagation circuit to which a microwave monolithic integrated circuit has a front-end amplifying circuit for low noises, and turns into a transmission line of the matching circuit of the input side of said front-end amplifying circuit from a superconducting material.

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

#### [0001]

[Field of the Invention] Especially this invention relates to the device of the structure which raises a RF property about a semiconductor device in the semiconductor device which processes the analog signal of a microwave millimeter wave.

#### [0002]

[Description of the Prior Art] High performance-ization of a semiconductor device progresses in recent years. In the device for a communication link The transistor using the compound semiconductor which operates to high frequency called Ka band (26.5-40GHz) and U band (40-60GHz) appears. An impedance matching circuit on this compound semiconductor substrate by the end of today with a transistor The microwave and monolithic integrated circuit (referred to as MMIC) formed in a monolithic came (ray KE Gupta etc.) to be announced. A microwave journal (A. KGupta, et.al.Microwave Journal), Nov.1982, pp.77-84. However, when the thing of the small ground receiving amplifier of satellite broadcasting service is considered, for example, the present condition is the preamp which amplifies the minute electric wave from a satellite, a local transmitter, a mixer amplifier machine, etc. being manufactured as a chip of 2-3mm dimension which became independent respectively, and the above-mentioned MMIC's connecting them by bonding WAIWA, and collected as one receiving amplifier. If it carries out the three above-mentioned chips to one chip, a chip is too large, and becomes disadvantageous on the manufacture yield, and it is made to manufacture as a separate chip, since each of a preamp, a local transmitter, and a mixer amplifier machine has a large area which the matching circuit occupies although it is a MMIC chip with a matching circuit including a transmission line.

#### [0003]

[Problem(s) to be Solved by the Invention] In MMIC, in order to make small area which a matching circuit occupies, there is the approach of making thin thickness (thickness of the substrate with which it is formed in the front face, H2, i.e., the matching circuit, of drawing 2 ) of a chip, and narrowing width of face (W2 of drawing 2 ) of a transmission line. However, if the width of face of a transmission line becomes narrow in this case, the electric resistance of a transmission line will become large, it will become the cause of a signal loss or noise generating, and un-arranging will occur. Especially the loss of the input matching circuit for the preamps for low noises is directly related to degradation as it is. If the height of a transmission line is made high even if it makes width of face of a transmission line small, electric resistance will not be increased in direct current. However, the width of face of the transmission line where the dielectric constant of a substrate is generally greatly in contact with the substrate that electric field concentrate on a substrate side and by contributing effectually to conduction only the thickness called the skin depth of a surface of metal on a high frequency is carrying out main contribution to the signal loss. The purpose of this invention is to offer the semiconductor device which made the chip area of MMIC small, removing the fault of the conventional technique of generating the width of face of a transmission line writing narrowly, and holding the good point of the above-mentioned conventional technique.

#### [0004]

[Means for Solving the Problem] This invention is a semiconductor device characterized by using a superconducting material for the transmission line (microstrip line) of a microwave monolithic integrated circuit. Or it is the semiconductor device characterized by using the propagation circuit to which a microwave monolithic integrated circuit has a front-end amplifying circuit for low noises, and turns into a transmission line of the matching circuit of the input side of said front-end amplifying circuit from a superconducting material.

[0005] (Operation) Since the superconducting material with which electric resistance becomes zero is used for the electrode of a transmission line or a device and electric resistance does not increase even if the width of face of the electrode of a transmission line or a device becomes very narrow, the semiconductor device of this invention has the description with the operation which can make a matching circuit including a transmission line small, and can make the chip size of MMIC small. In the case of the preamp for low noises, if a superconducting material is used for a matching circuit, it not only can make the area small, but it can make resistance of an input side low. Since resistance of a gate electrode can be made low when a superconducting material is used as a gate electrode of the transistor contained in a preamp, there is the description with the operation which inhibits generating of a noise.

[0006]

[Embodiment of the Invention] Next, the example of this invention is explained with reference to a drawing. Drawing 1 shows the conceptual perspective view of the important part of the semiconductor device of this invention, i.e., the inductive line part using the transmission line (called a microstrip line in this case) in MMIC. The oxide ceramics of the shape of perovskite which consists of an yttrium (Y), barium (Ba), copper (Cu), and oxygen (O) as an ingredient of the superconduction material transmission line 2 are used for this example, using the gallium arsenide (GaAs) substrate 1 as a substrate of MMIC, and it is the substrate thickness H1. It inserts and is width of face W1. The transmission line 2 constitutes the microstrip line with the earth electrode 3 formed in the substrate rear face. The above-mentioned superconduction material system shows the superconduction property that electric resistance becomes zero near the 77k of liquid nitrogen temperature. In order to prepare the above-mentioned superconduction material as film in up to a GaAs substrate, it carries out by the magnetron sputtering using argon gas in an oxygen ambient atmosphere. As a transmission-line pattern, in order to carry out pattern formation of the above-mentioned superconduction material film, it carries out by ion mealing using argon gas.

[0007] In this example, it has the effectiveness that even for example, 1-micrometer pattern can decrease the transmission-line pattern of 5-micrometer width of face with the conventional processing technique conventionally, and a chip size can be decreased to 1/about 5 in this case. In order to strengthen adhesive strength to the film prepared on a GaAs substrate and its substrate, it is the thickness (for example, 500A) of the range thinner than a high frequency skin depth about usual state electrical conduction layers, such as titanium (Ti), and it is also possible to prepare, just before carrying out spatter formation of the superconduction material. Moreover, it is also clear that forming the multilayers of titanium metallurgy in the upper part of the above-mentioned superconduction material film for the purpose of making easy electric contact on the superconduction material film etc. goes into the right range of this invention.

[0008] If the propagation circuit which consists of superconduction material represented with the above-mentioned inductive line uses as a matching circuit of the input side of a front-end amplifying circuit, it decreases as compared with the case where resistance of an input side does not use, and considers as the preamp of a low noise, and an effective thing is clear.

[0009] Moreover, when using the propagation circuit which consists of superconduction material represented with the above-mentioned inductive line as a gate electrode of a transistor, it is distinct that the low noise property of a transistor improves by decreasing as compared with the case where gate electrode resistance does not use.

[0010] In addition, in an example, although only the specific ingredient [ material / substrate material or / superconduction ] was described, it is clear that this invention is not limited only to the ingredient. For example, although the combination of one kind, such as silicon (Si), other compound semiconductors, and a dielectric, or varieties can also be guessed easily, and

superconduction material is also doubled with the ingredient and a membrane formation technique, a pattern formation technique is also doubled with an advance of a technique and it may change to a substrate, it is clear that it can go into the right range of this invention even in such a case.

[0011]

[Effect of the Invention] As mentioned above, according to this invention, occupancy area of the transmission-line circuit in MMIC can be made small by the device which narrows width of face of a transmission line by the above-mentioned configuration as explained to the detail. For example, it becomes possible not to drop a function on the inductance circuit using the superconduction material transmission line 2 as shows the inductance circuit using the usual state electrical conduction material transmission line 5 shown by drawing 2 by drawing 1, or to raise a function, and to make area small. Here, it is the width of face W1 of a transmission line. W2 Distance H1 with earth electrodes 3 and 6 H2 It fluctuates-like proportionally respectively. By the ability making small occupancy area of the transmission-line circuit in MMIC, the chip area of MMIC can be made small, if it is about [ raising the manufacture yield of MMIC ], and the same chip area, various functions can be accumulated more on a MMIC chip, and the semiconductor device which can attain low-pricing, multi-functionalization, and easy-ization of maintenance will be obtained. If a superconducting material is used as a gate electrode of the transistor contained in a preamp, the effectiveness of decreasing a noise figure and raising a low noise property will be acquired.

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**TECHNICAL FIELD**

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**[Field of the Invention]** Especially this invention relates to the device of the structure which raises a RF property about a semiconductor device in the semiconductor device which processes the analog signal of a microwave millimeter wave.

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**PRIOR ART**

[Description of the Prior Art] High performance-ization of a semiconductor device progresses in recent years. In the device for a communication link The transistor using the compound semiconductor which operates to high frequency called Ka band (26.5-40GHz) and U band (40-60GHz) appears. An impedance matching circuit on this compound semiconductor substrate by the end of today with a transistor The microwave and monolithic integrated circuit (referred to as MMIC) formed in a monolithic came (ray KE Gupta etc.) to be announced. A microwave journal (A. KGupta, etal.Microwave Journal), Nov.1982, pp.77-84. However, when the thing of the small ground receiving amplifier of satellite broadcasting service is considered, for example, the present condition is the preamp which amplifies the minute electric wave from a satellite, a local transmitter, a mixer amplifier machine, etc. being manufactured as a chip of 2-3mm dimension which became independent respectively, and the above-mentioned MMIC's connecting them by bonding WAIWA, and collected as one receiving amplifier. If it carries out the three above-mentioned chips to one chip, a chip is too large, and becomes disadvantageous on the manufacture yield, and it is made to manufacture as a separate chip, since each of a preamp, a local transmitter, and a mixer amplifier machine has a large area which the matching circuit occupies although it is a MMIC chip with a matching circuit including a transmission line.

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**EFFECT OF THE INVENTION**

[Effect of the Invention] As mentioned above, according to this invention, occupancy area of the transmission-line circuit in MMIC can be made small by the device which narrows width of face of a transmission line by the above-mentioned configuration as explained to the detail. For example, it becomes possible not to drop a function on the inductance circuit using the superconduction material transmission line 2 as shows the inductance circuit using the usual state electrical conduction material transmission line 5 shown by drawing 2 by drawing 1, or to raise a function, and to make area small. Here, it is the width of face W1 of a transmission line. W2 Distance H1 with earth electrodes 3 and 6 H2 It fluctuates-like proportionally respectively. By the ability making small occupancy area of the transmission-line circuit in MMIC, the chip area of MMIC can be made small, if it is about [ raising the manufacture yield of MMIC ], and the same chip area, various functions can be accumulated more on a MMIC chip, and the semiconductor device which can attain low-pricing, multi-functionalization, and easy-ization of maintenance will be obtained. If a superconducting material is used as a gate electrode of the transistor contained in a preamp, the effectiveness of decreasing a noise figure and raising a low noise property will be acquired.

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**TECHNICAL PROBLEM**

[Problem(s) to be Solved by the Invention] In MMIC, in order to make small area which a matching circuit occupies, there is the approach of making thin thickness (thickness of the substrate with which it is formed in the front face, H2, i.e., the matching circuit, of drawing 2 ) of a chip, and narrowing width of face (W2 of drawing 2 ) of a transmission line. However, if the width of face of a transmission line becomes narrow in this case, the electric resistance of a transmission line will become large, it will become the cause of a signal loss or noise generating, and un-arranging will occur. Especially the loss of the input matching circuit for the preamps for low noises is directly related to degradation as it is. If the height of a transmission line is made high even if it makes width of face of a transmission line small, electric resistance will not be increased in direct current. However, the width of face of the transmission line where the dielectric constant of a substrate is generally greatly in contact with the substrate that electric field concentrate on a substrate side and by contributing effectually to conduction only the thickness called the skin depth of a surface of metal on a high frequency is carrying out main contribution to the signal loss. The purpose of this invention is to offer the semiconductor device which made the chip area of MMIC small, removing the fault of the conventional technique of generating the width of face of a transmission line writing narrowly, and holding the good point of the above-mentioned conventional technique.

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**MEANS**

[Means for Solving the Problem] This invention is a semiconductor device characterized by using a superconducting material for the transmission line (microstrip line) of a microwave monolithic integrated circuit. Or it is the semiconductor device characterized by using the propagation circuit to which a microwave monolithic integrated circuit has a front-end amplifying circuit for low noises, and turns into a transmission line of the matching circuit of the input side of said front-end amplifying circuit from a superconducting material.

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OPERATION

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## DESCRIPTION OF DRAWINGS

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### [Brief Description of the Drawings]

[Drawing 1] It is drawing having shown the conceptual diagram for the principal part of the semiconductor device of this invention.

[Drawing 2] It is drawing having shown the conceptual diagram of the conventional semiconductor device of a function to drawing 1.

### [Description of Notations]

- 1 Four GaAs substrate
- 2 Superconduction Material Transmission Line
- 5 Usual State Electrical Conduction Material Transmission Line
- 3 Six Earth electrode

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(19)日本国特許庁 (JP)

## (12) 公開特許公報 (A)

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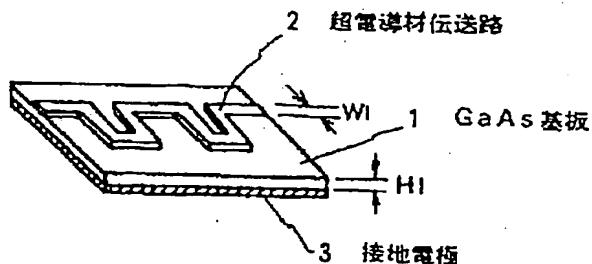
(71)出願人 000004237  
 日本電気株式会社  
 東京都港区芝五丁目7番1号  
 (72)発明者 鈴木 克己  
 東京都港区芝五丁目7番1号 日本電気株式会社内  
 (74)代理人 弁理士 京本 直樹 (外2名)

## (54)【発明の名称】 半導体装置

## (57)【要約】

【課題】 MMIC機能を落とさずに、整合回路の占める面積を小さくする。

【解決手段】 マイクロ波モノリシック集積回路の伝送路(マイクロストリップライン)に超伝導材料を用いる。または、マイクロ波モノリシック集積回路が低雑音用の前置増幅回路を有し、前記前置増幅回路の入力側の整合回路の伝送路に超伝導材料からなる伝送回路を用いる。



## 【特許請求の範囲】

【請求項1】マイクロ波モノリシック集積回路の伝送路(マイクロストリップライン)に超伝導材料を用いたことを特徴とする半導体装置。

【請求項2】マイクロ波モノリシック集積回路が低雑音用の前置増幅回路を有し、前記前置増幅回路の入力側の整合回路の伝送路に超伝導材料からなる伝送回路を用いたことを特徴とする半導体装置。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は半導体装置に関し、特にマイクロ波ミリ波のアナログ信号を処理する半導体装置において、高周波特性を向上させる構造の工夫に関する。

## 【0002】

【従来の技術】近年、半導体装置の高性能化が進み、通信用のデバイスでは、Ka帯(2.6. 5~40GHz)やU帯(40~60GHz)という高周波まで動作する化合物半導体を用いたトランジスタが出現し、今日ではインピーダンス整合回路も該化合物半導体基板上にトランジスタとともに、モノリシックに形成するマイクロ波・モノリシック集積回路(MMICと呼ばれる)が発表されるようになった(エイ・ケー・グプタ等、マイクロウェーブジャーナル(A. K. Gupta, et al. Microwave Journal), Nov. 1982, pp. 77-84)。しかしながら、たとえば衛星放送の小型地上受信アンプのことを考えると、前述のMMICは、衛星からの微小電波を増幅する前置増幅器、局部発信器、ミキサー・アンプ器などが、おのの独立した2~3mm寸法のチップとして製作され、それらをボンディング・ワイヤで連結してひとつの受信アンプとしてまとめられているのが現状である。前置増幅器、局部発信器、ミキサー・アンプ器のそれぞれが伝送路を含む整合回路をもったMMICチップであるが、その整合回路の占有する面積が大きいために、上記三つのチップをひとつのチップにするとチップが大きすぎ、製作歩留まり上不利となり、別々のチップとして製作させていく。

## 【0003】

【発明が解決しようとする課題】MMICにおいて、整合回路の占める面積を小さくするには、チップの厚さ(図2のH<sub>1</sub>、すなわち整合回路が表面に形成されている基板の厚さ)を薄くし、かつ伝送路の幅(図2のW<sub>1</sub>)を狭くする方法がある。しかし、この場合、伝送路の幅が狭くなると、伝送路の電気抵抗が大きくなり、信号ロスや雑音発生の原因になり不都合が発生する。特に、低雑音用の前置増幅器用の入力整合回路のロスは、そのまま性能低下に直接関係する。伝送路の幅を小さくしても、伝送路の高さを高くすれば、直流通じて電気抵抗を増大させない。しかし、基板の誘電率が一般に大きく電

界が基板側に集中すること、また、高い周波数では金属表面のスキンデプスと呼ばれる厚さしか実効的に伝導に寄与しないことにより、基板に接している伝送路の幅が信号ロスに対して主要な寄与をしている。本発明の目的は、伝送路の幅を狭くしたために発生する従来技術の欠点を除去し、上記従来技術の良い点を保持したままで、MMICのチップ面積を小さくさせたところの半導体装置を提供することにある。

## 【0004】

10 【課題を解決するための手段】本発明は、マイクロ波モノリシック集積回路の伝送路(マイクロストリップライン)に超伝導材料を用いたことを特徴とする半導体装置である。または、マイクロ波モノリシック集積回路が低雑音用の前置増幅回路を有し、前記前置増幅回路の入力側の整合回路の伝送路に超伝導材料からなる伝送回路を用いたことを特徴とする半導体装置である。

【0005】(作用)本発明の半導体装置は、伝送路またはデバイスの電極に電気抵抗がゼロになる超伝導材料を用いているために、伝送路やデバイスの電極の幅が極めて狭くなっても、電気抵抗が増加することがないで、伝送路を含む整合回路を小さくでき、MMICのチップサイズを小さくできる作用をもつ特徴がある。低雑音用の前置増幅器の場合には、整合回路に超伝導材料を用いると、その面積を小さくできるばかりでなく、入力側の抵抗を低くすることができる。前置増幅器に含まれるトランジスタのゲート電極として超伝導材料を用いた場合にはゲート電極の抵抗を低くできるので雑音の発生を抑制する作用をもつ特徴がある。

## 【0006】

30 【発明の実施の形態】次に本発明の実施例について図面を参照して説明する。図1は本発明の半導体装置の重要な部分、すなわちMMICにおける伝送路(この場合マイクロストリップラインとも呼ばれる)を利用したインダクティブライン部分の概念斜視図を示したものである。本実施例は、MMICの基板として、珪化ガリウム(GaAs)基板1を用い、超伝導材伝送路2の材料としてはイットリウム(Y), バリウム(Ba), 銅(Cu), 酸素(O)からなるペロブスカイト状の酸化物セラミックスを用い、基板厚さH<sub>1</sub>をはさみ、幅W<sub>1</sub>の伝送路2が基板裏面に形成された接地電極3によりマイクロストリップラインを構成している。上記超伝導材系は、液体窒素温度の77K近傍にて電気抵抗がゼロになる超伝導特性を示す。GaAs基板上へ上記超伝導材を膜として設けるには、酸素雰囲気中でアルゴンガスを用いたマグネットロクスバッタで行う。伝送路パターンとして、上記超伝導材膜をパターン形成するには、アルゴンガスを用いたイオンミーリングで行う。

40 【0007】本実施例では、従来5μm幅の伝送路パターンを例えれば1μmパターンまで従来の加工技術をもつて減少させることができ、この場合、チップサイズをほ

ば5分の1に減少させることができる効果をもつ。G a A s 基板や、その基板上に設けた膜に対して接着力を強めるために、チタン (T i) 等の常電導層を高周波スキンデプスよりも薄い範囲の厚さ (例えば500オングストローム) で、超伝導材をスパッタ形成する直前に設けることも可能である。また上記超伝導材膜の上部に、超伝導材膜との電気的接触を容易にすることなどを目的にチタンや金の多層膜を形成することも本発明の権利範囲に入ることは明らかである。

【0008】上記インダクティブラインで代表される超伝導材からなる伝送回路が前置増幅回路の入力側の整合回路として用いると、入力側の抵抗が用いない場合と比較し減少し低雑音の前置増幅器とし、有効であることが明らかである。

【0009】また上述インダクティブラインで代表される超伝導材からなる伝送回路をトランジスタのゲート電極として用いる場合には、ゲート電極抵抗が用いない場合と比較し減少することにより、トランジスタの低雑音特性が向上することが明らかである。

【0010】なお、実施例において、基板材や超伝導材について、特定の材料についてのみ述べたが、その材料のみに本発明が限定されないことは明らかである。例えば、基板に対しては、シリコン (S i)、他の化合物半導体、誘電体などの一類、または多種類の組み合わせも容易に類推可能であるし、超伝導材もその材料、成膜技術、パターン形成技術も、技術の進歩に合わせて変わり得るが、その場合でも本発明の権利範囲に入り得ることは明らかである。

## \*【0011】

【発明の効果】以上、詳細に説明したとおり、本発明によれば、上記構成により、伝送路の幅を狭くする工夫によって、M M I Cにおける伝送路回路の占有面積を小さくできる。例えば図2で示す常電導材伝送路5を用いたインダクタンス回路を、図1で示すような、超伝導材伝送路2を用いたインダクタンス回路に、機能を落とさず、または機能を向上させて面積を小さくすることが可能になる。ここで、伝送路の幅W<sub>1</sub>とW<sub>2</sub>は、接地電極10 3, 6との距離H<sub>1</sub>とH<sub>2</sub>におのおの比例的に増減する。M M I Cにおける伝送路回路の占有面積を小さくできることにより、M M I Cのチップ面積を小さくでき、M M I Cの製造歩留まりを向上させるばかりか、同一チップ面積ならば、より多機能をM M I Cチップ上に集積でき、低価格化、多機能化、保守の容易化が図れる半導体装置が得られる。前置増幅器に含まれるトランジスタのゲート電極として超伝導材料を用いると、雑音指数を減少させ低雑音特性を向上させる効果が得られる。

## 【図面の簡単な説明】

【図1】本発明の半導体装置の主要部分の概念図を示した図である。

【図2】図1に対する機能の従来の半導体装置の概念図を示した図である。

## 【符号の説明】

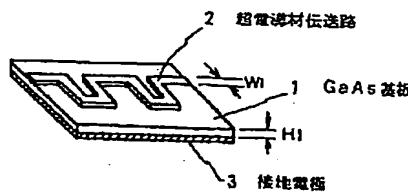
1, 4 G a A s 基板

2 超伝導材伝送路

5 常電導材伝送路

3, 6 接地電極

【図1】



【図2】

